

REMARKS

Claims 16-23 and new claims 38-51 remain in this application. The features of new claims 38-51 were taken from the claims canceled, without prejudice, so that no new matter has been presented in the new claims. Support for the language added to amended claim 1, and the H₂/halogen ratios is found at page 5, lines 9-15, and elsewhere throughout the specification.

Claims 16-23 stand rejected under 35 U.S.C. 103(a) as unpatentable over McNallan et al. "Formation of Carbon Coatings on Silicon Carbide by Reactions In Halogen Containing Media" in view of Cooper 5,482,602 (hereinafter "602").

It is asserted in the rejection that the McNallan article teaches etching in halogen and hydrogen-containing gases ... **"to provide essentially only diamond or diamond and carbon on said ceramic matrix"**. In fact, at the time of publication of the McNallan article, the sentence on the top of page 560 "An alternative method for formation of **diamond or diamond like carbon** films ..." was speculative. In fact, at the end of the paragraph, it is positively stated that what is formed by the disclosed process is carbon: "This paper addresses the thermodynamics and kinetics of **carbon formation** on several metal carbide surfaces, which may be useful in MEMS devices."

Attached to this response is a copy of page 337, HANDBOOK OF CARBON, GRAPHITE, DIAMOND AND FULLERENES, by Hugh O. Pierson © 1993. Diamond-like carbon (DLC) is a meta-stable carbon, which is neither diamond nor graphite. It is actually diamond, which is produced by the claimed process (nanocrystalline diamond), and not DLC. Note that in Fig. 1 on page 561 of the McNallan article that the mole ratio of H₂ to Cl₂ is greater than 1, and that page 562 states that "a large amount of graphite was formed during the reaction. Also note that page 563 clearly states that "the TiC experiments did not produce diamond or diamond like carbon." Fig. 4 (page 564) teaches that a non-crystalline carbon structure was formed characteristic of diamond-like carbon (DLC) - but not diamond (because of the excess H₂ contained in the reaction mixture).

In the Summary and Conclusions (page 564) it is stated that when the gas also contains H₂ the films formed have structures like diamond like carbon, but nowhere in the McNallan et al. article is diamond formed.

Cooper et al. '602 again teaches depositing diamond-like carbon (DLC) by ion-deposition. Not only is the Cooper et al. '602 patent directed to a deposition process (rather than the transformation of a metal carbon surface into actual crystalline diamond), but the deposited material is DLC, not crystalline diamond.

It is submitted, therefore, that the rejection based on the McNallan et al. article, in view of Cooper et al. '602, should be withdrawn.

Claims 16-23 stand further rejected under 35 U.S.C. §103(a) as unpatentable of Gogotsi, "Carbon Coatings on Silicon Carbide by Reaction with Chlorine-Containing Gases".

In the Gogotsi et al. article, Fig. 4 shows a molar ratio of 1:1, Cl₂:H₂, resulting in carbon formation. As stated at page 2 of the article, under "Results", "From the results shown in Fig. 2-5, carbon formation is expected in reactions with both Cl₂ and Cl₂-H₂."

Similarly, Fig. 7(b) again shows that at a 1:1 ratio of H₂:Cl₂, amorphous carbon is formed.

Figures 8(a) and (b) show that treatment of SiC powder result in a small amount of diamond (less than 1%) having a size of a few micrometers, having no well shaped crystals, wherein the crystals are smaller than 1 micrometer:

"The amount of diamond in the powder is small (probably <1%), but diamond regions are clearly visible under a microscope. Some of them produce a Raman band of diamond which is not accompanied by SiC or graphite peaks [Fig. 8(b)]. This means that the size of these regions is of the order of a few micrometers; however, the crystals are probably smaller than 1 micrometer."

Although diamond was detected in the experiments described in this paper, this paper does not show that a hard carbon surface (coating) containing nanocrystalline diamond can be produced by chlorination of silicon carbide monolithic bearing surfaces. The experiments performed in this work were performed on 1 micron β SiC powder, not on macroscopic components. Although diamond was detected by Raman spectroscopy in the reaction products of chlorination (see figures 8, 9, and 10), it was found only in selected

samples, and was not present in other regions from the same samples (see figures 6 and 7). Note that diamond made up only a small fraction of the total reaction products. That small amounts of diamond were detected in these powders does not show that diamond-containing coatings were produced on the SiC. Specifically, when carbon coatings on SiC particles were examined in transmission electron microscopy (see Figure 13), the were found to be graphitic (note the electron diffraction patter in Figure 13). When treatments were performed under conditions to maximize diamond formation, continuous carbon coatings on the particles were not observed (see Figure 14).

The conclusion of this paper regarding diamond formation in this process is summarized in conclusion 3:

3. When the hydrogen-chlorine gas mixture was used with an appropriate ratio of Cl_2 and H_2 , traces of nano- or micro- crystalline diamond were found.

These traces of diamond would not be sufficient to affect the physical and mechanical properties of the film that are important in engineering applications (which were not reported and could not have been measured on the samples produced in the experiments described in this paper).

As set forth in applicants' specification at the bottom of page 6 and page 7, applicants claimed invention forms large volumes of nano- and micro- crystalline diamond on monolithic parts at a H_2 : Halogen ratio of at least 0.3 to 2.

"In accordance with the present invention, relatively **large volumes of nano- and microcrystalline diamond** can be synthesized at low cost, by the extraction of a silicon from silicon carbide in chlorine-containing gases and preferably at ambient pressure, and preferably at temperatures not exceeding 1,000°C. No plasma or other high-energy activation is required, thus providing an opportunity for large-scale production. The presence of at least 0.3 mole of hydrogen for each two moles of halogen in the gas mixture leads to a complete conversion of SiC to diamond, with the average crystallite size of 5-10 nm, and without deterioration of the diamond to graphitic carbon as the reaction proceeds with time. Thick and thin coatings, polycrystalline powders with any grain size or micro-components can be made in accordance with the method of the present invention. The linear diamond growth kinetics, accomplished in accordance with the method

of the present invention, allows transformation of metal carbide to diamond to any depth, ultimately until the whole SiC particle or component is transformed to diamond. Nanocrystalline diamond coatings demonstrate hardness values in excess of 50 GPa and Young's modulus up to 800 GPa."

Further, as set forth on page 22 of applicants' specification, diamond nanocrystalline coatings can be achieved in accordance with the claimed invention:

Addition of hydrogen to the gas to achieve a chlorine/hydrogen ratio of 2:0.75 to 2:1 resulted in changes in the appearance and structure of carbon coatings. . . . TEM shows that these coatings were built of diamond nanocrystals with the average size of 5-10 nm (FIG. 4b). In SAD pattern from this film, sharp Bragg reflections are visible up to the order of (800), indicating good crystallinity. No scattering intensity from either graphite or amorphous carbon can be seen, suggesting that the film is pure diamond."

Since the claimed invention is neither disclosed nor suggested in the inventors prior art articles, it is submitted that the rejections should be withdrawn.

It is submitted that all claims are now of proper form and scope for allowance. Early and favorable consideration is respectfully requested.

Dated: December 30, 2003

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